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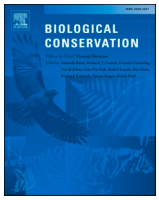

Psychological and physical connections with nature improve both human well-being and nature conservation: A systematic review of meta-analyses

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ABSTRACT

Despite growing evidence that "connectedness" of humans with nature creates multiple benefits for both humans and nature, these benefits are not fully considered by health and conservation policymakers. Studies are scattered across scientific disciplines including health, education, psychology and biology, making it difficult to get a complete overview. Here, we conduct a systematic review, focused on recent meta-analyses that investigate impacts of psychological and/or physical connection with nature on human health and well-being and on attitudes and actions that promote nature conservation. By "psychological connection" we mean the extent to which people see themselves as part of nature and by "physical connection" we mean contact with natural areas. We identified 16 relevant meta-analyses covering 832 independent studies. We found consistent conclusions across geographically diverse experimental studies that physical connection with nature improved human cognition, social skills, physical and mental health, and psychological connection to nature. Experiments also showed that psychological connection with nature had significant positive impact on pro-environmental behaviors and values. Correlational studies supported experimental results and, in addition, found psychological connection with nature positively correlated with mental and physical health. Studies are biased toward adults rather than children and away from southern regions (Africa, Oceania and South America). Overall, our review suggests a critical role for psychological and physical human-nature connections in developing a sustainable future. Although experimental studies are rare, conducting cross-cultural experimental research is needed if governmental and non-governmental stakeholders, researchers and citizens are to develop appropriate actions toward achieving United Nations Sustainable Development Goals.

1. Introduction

Human activities are threatening natural systems and human health (He and Silliman, 2019; Rutz et al., 2020; Tollefson, 2020). To counter these negative impacts, four different conservation strategies have been proposed over the past 50 years (Mace, 2014): "*Nature for itself*" in which conservation actions protect nature from people, "*nature despite people*" in which conservation actions restore degraded environments, "*nature for people*" which focuses on the importance of nature for human well-being, health and economy and "*people and nature*" which focuses on bidirectional positive relationships between humans and other living beings (Howe et al., 2014). This last view, that human well-being and ecosystem health are coupled, has increasing evidence from the scientific literature. Several recent reports have concluded that success in reaching the United Nations Sustainable Development Goals and in achieving climate-resilient development necessitates incorporating maintenance of ecosystem health into planning for societal development (IPBES, 2019; IPCC, 2019; Pörtner et al., 2021; IPCC, 2022).

Here, we focus on the "people and nature" concept, which explores the psychological, societal and cultural factors that should promote a sustainable, synergistic and resilient relationship between humans and other living beings (Howe et al., 2014; Mace, 2014; Whitburn et al., 2020). Peoples' differing worldviews - defined by Matthews (2009) as the "overall perspective on life that sums up what we know about the

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world"- are expected to be important influences on how citizens and stakeholders perceive, react to, and support public policies (Matthews, 2009; Mayer, 2018). In order to discuss existing worldviews about human-nature relationships, we identify below two categories that are easy to describe and that represent extremes of a continuum in peoples' perception of the relative importance of humans and non-human nature.

The ecocentric (or biospheric) worldview is "nature-centered" and assumes that humans are a part of the natural world. This may include the idea that humans have the same intrinsic value as other living beings and should live "in harmony" with them (Oelschlaeger, 1992; Salmón, 2000; Louv, 2008). By contrast, the anthropocentric worldview is "human-centered," assuming that humans are the most important element in the system and that all other things exist to serve or be exploited by humans. In this latter worldview, nature is seen as a resource that can and should be controlled and managed by humans (Gagnon Thompson and Barton, 1994; Stokols, 1990).

In anthropocentric worldviews, which have become particularly well-developed in some sectors of industrialized societies (Stokols, 1990), humans see themselves as disconnected from the rest of nature (Barrable and Booth, 2022), both desiring and expecting to dominate and exploit other living beings through the development of new technologies. This psychological disconnection between humans and nature is emphasized by physical disconnection between people and the natural world through increasing urbanization and reduced opportunities to experience real nature, ultimately leading to the so-called "extinction of experience" with nature (Miller, 2005; Cazalis et al., in press). Both psychological and physical disconnection from the natural world may lead people to develop destructive habits, norms and practices toward nature, with adverse consequences for humans themselves (Stokols, 1990; Louv, 2008; Butchart et al., 2010; Estes et al., 2011; Brenner et al., 2015).

At the other end of the nature-connectedness spectrum, some traditional pre-industrialized societies do not make clear distinctions between humans and nature, considering non-humans (animals and plants) as full and equal members of their own social community with whom they must maintain sustainable and reciprocal interactions (Alcorn, 1993; Salmón, 2000; Descola, 2013; Ojalehto Mays et al., 2020). Such a worldview has been shown to encourage sustainable norms and practices toward nature (Alcorn, 1993; Atran et al., 2002; Salmón, 2000; Castleden et al., 2009). For example, one traditional society with an ecocentric worldview engaged in more practices favoring forest biodiversity than a neighboring traditional population, living in the same environment, that did not share such beliefs (Atran et al., 2002). In a second example, the traditional Native American "huu-ay-aht" society near Vancouver has implemented a management strategy for their forest whose name translates as "everything interacts, everything is one." "Everything" in this case includes animals, plants and humans, and the result has been sustainable forest management (Castleden et al., 2009).

How do worldviews develop? Children, even in industrialized societies, tend to display spontaneous attraction to nature, described either as biophilia (Kellert and Wilson, 1993) or as "childish animism" (Piaget, 1929). Biophilia may indeed be "childish" in the sense of being lost as we age. Younger children showed higher "connection" with non-humans than adolescents (Hughes et al., 2019), and North American children under 9 years-old did not prioritize humans over non-human animals in a moral game, while adults did (Wilks et al., 2021).

Our views on the degree and nature of resemblances between ourselves and other species are related to our behavior toward those species. Children who tended to assign intentionality and emotions to non-humans showed higher concern for the well-being of those non-humans than did other children (Gebhard et al., 2003). Similarly, adults from industrialized societies with a higher tendency to anthropomorphize non-humans engaged in more pro-environmental behavior than did humans in the same societies who were less prone to anthropomorphism (Waytz et al., 2010).

Individuals in most industrialized nations seem to be influenced by worldviews that underestimate the actual impacts of nature on their welfare and behavior. Nisbet and Zelenski (2011) report that while individuals' happiness and environmental concern increased after taking an outdoor walk compared to an indoor walk, urban residents participating in a forecasting task systematically underestimated the positive impact on their daily lives of being exposed to a natural environment. This type of misunderstanding is problematic since it means that a worldview can prevent someone from correctly perceiving the benefits of being in nature, thereby facilitating behaviors with negative impacts on both health and environmental decision-making. In consequence, a worldview which places high value on technology might downplay the perceived efficiency of nature-based solutions for reaching sustainability targets.

An important aspect of peoples' worldview is their psychological connection with nature, the extent to which humans see themselves as part of nature. This trait is most frequently described in the literature as "Human-Nature Connectedness" abbreviated as HNC and includes different concepts and metrics (e.g. nature relatedness, connectedness to nature, inclusion of nature in self, new environmental paradigm; see Tam, 2013 for a review). Hundreds of correlational studies show that HNC is linked to human welfare and nature conservation in industrialized countries and dozens of experimental studies show that being physically connected with nature (e.g., taking a walk in the forest) increases HNC (meta-analysis in Barragan-Jason et al., 2021). Yet, studies on this topic are scattered across various scientific disciplines such as health, education, psychology and biology, making it difficult to create a complete and clear overview of findings. This difficulty may explain why the benefits for human health and nature conservation of physical and psychological connections with nature are still largely underappreciated by citizens in their daily lives (Nisbet and Zelenski, 2011) and rarely considered or promoted by public policies. Here, we fill this research gap by including a wide range of disciplines, from biological to social science studies, in a systematic review of meta-analyses on the effects of psychological and physical connection with nature on human welfare and nature conservation. Our review, which covers 832 independent studies and 1876 effect sizes, is aimed at informing policy-makers in conservation and education.

2. Material and methods

2.1. Review question

We applied a broad definition of connections with nature to include both psychological connection - the extent to which people see themselves as part of nature - and physical connection that arises from contact with natural areas. We used Web of Science (WoS) from 1900 to February 2022 to identify meta-analyses dealing with impacts of connections with nature on human welfare and/or nature conservation. We then followed the PRISMA guidelines to conduct the systematic review of these meta-analyses (O'Dea et al., 2021) using the RepOrting standards for Systematic Evidence Syntheses (ROSES) tool (https://www.roses-reporting.com/; Fig. 1).

2.2. Literature search and inclusion criteria

We selected for inclusion only quantitative meta-analyses of independent studies following a robust and transparent methodology (PRISMA) and written in English. For instance, we did not include reviews, opinions, scoping reviews or meta-analysis of original unpublished data. We included both experimental and correlational studies, provided that they measured at least one physical or psychological connection with nature and at least one outcome falling within the scope of the present study. "Experimental studies" refer to papers studying the impact of an experimentally controlled or manipulated factor on an outcome variable while "correlational studies" assess observed

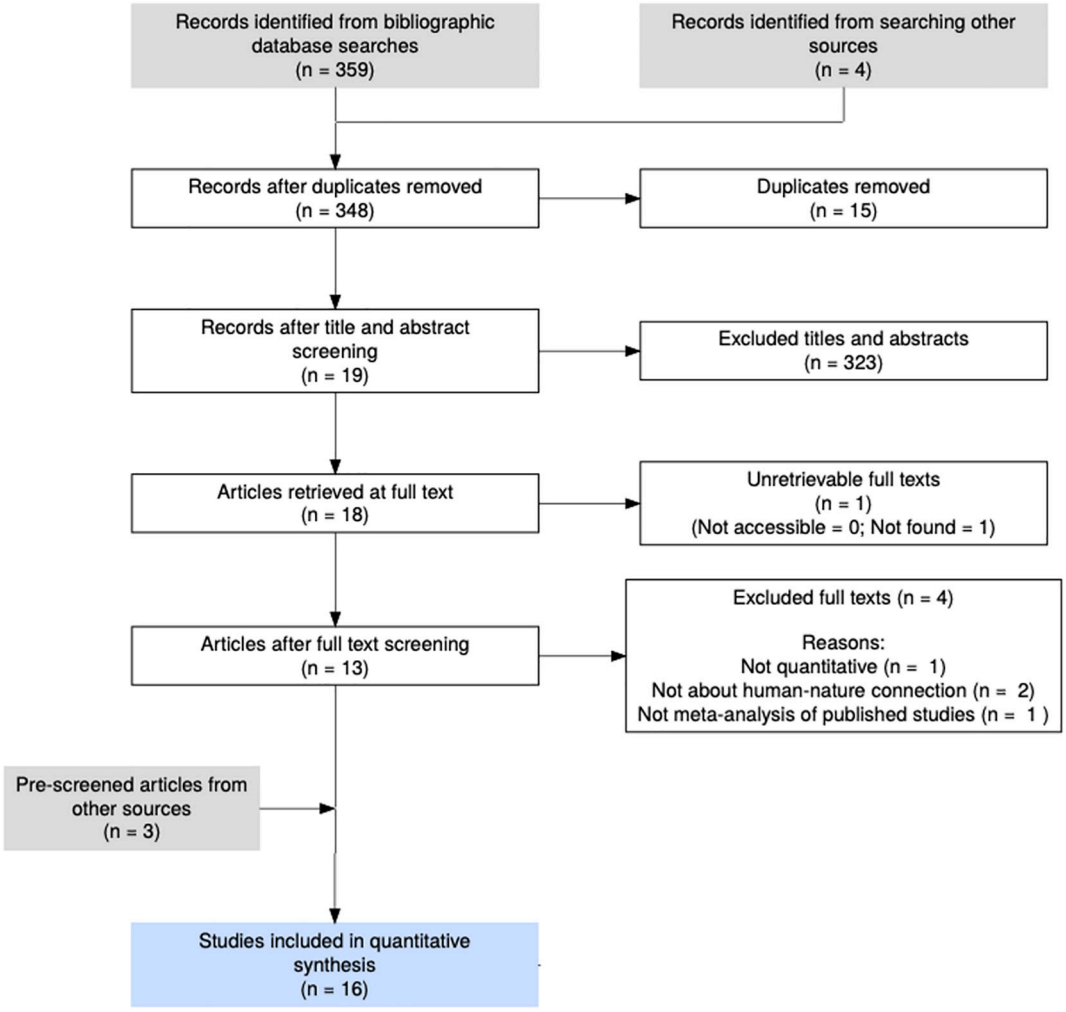

Fig. 1. PRISMA flow diagram describing the different steps of the systematic review, from identification to inclusion.

relationships between two variables (Table 1). The distinction between the two is important, since only experimental studies can identify causality. For example, if people in good health were more likely to seek experience with nature (as a reviewer suggests), a positive association should be generated between good health and connection with nature that would be caused, not by an effect of connection with nature on health, but by the opposite, an effect of health on nature connection. This positive association would appear in studies that we describe as "correlative." On the other hand, if human subjects were divided into groups chosen to be equivalent in their status of health and the groups were then given different experiences of nature, any differences that developed between the groups could be interpreted as effects of the difference in their treatment. This we would class as an experimental study. In general, such studies use manipulations to estimate the influence of one variable on another and to identify the nature and direction of causality.

2.3. Study selection

We based our search terms on a previous meta-analysis on a similar topic (Barragan-Jason et al., 2021) with search terms corresponding to the three main factors of interest (nature welfare, human welfare and connections with nature). We used the following search terms: meta-analys* AND conservation, meta-analys* nature, meta-analys* AND well-being, meta-analys* AND welfare, meta-analys* AND pro-environment*, meta-analys* AND natur* AND connect* (WoS format) with "Title word" and "English language" options. We obtained 359 records identified through database searching and 4 records identified in other published papers (see Fig. 1). Title, authors, year of publication, abstract and full references were extracted in an excel file.

2.4. Data screening

One researcher with high expertise in the topic screened all the records from "title and abstract" (Fig. 1). After removing duplicates (N = 15) and articles out-of-the scope (e.g., not about physical or psychological connection with nature; not English), we obtained 19 records. One full text was not available even after emailing the corresponding author. The remaining 18 full-texts were then screened. At the end of the screening, four records were removed: two records were out of scope, one record was qualitative and one was not a meta-analysis of independent studies but a meta-analysis of original data. Three additional records were identified from a previous study (pre-screened papers; Fig. 1).

2.5. Data extraction and coding

At the end of the process, **16 meta-analyses** met our eligibility criteria (Fig. 1). These 16 meta-analyses covered 832 independent studies with a total of 1876 effect sizes (Table 1). Following previous meta-analyses (e.g. Barragan-Jason et al., 2021; Mackay and Schmitt, 2019), we identified "age", "sample size", "world region" and "type of

Table 1
Description of the meta-analyses included in the review.

Authors	Nature connection	Outcomes	Study design	Research area	Framework
Barragan-Jason et al., 2021	Psychological (HNC)	PEB, mental and physical health	Corr & Exp	Conservation	People and nature: biophilia
Bowler et al., 2010	Mixed contact with nature	Cognition, mental and physical health	Exp	Health	Nature for people: health benefits (SRT)
Buxton et al., 2021	Natural sounds	Mental and physical health	Corr & Exp	Interdisciplinary	Nature for people: health benefits (SRT, ART); People and Nature: biophilia
Capaldi et al., 2014	Psychological (HNC)	Mental health	Corr	Psychology	People and Nature: biophilia
Coventry et al., 2021	Outdoor activities	Mental health	Corr & Exp	Health	Nature for people: health benefits (SRT; ART)
Daryanto and Song, 2021	Psychological (PA)	PEB and intentions	Corr	Economics	Nature despite people: landscape management
Djernis et al., 2019	Nature-based mindfulness	Mental and physical health; social domain	Exp	Health	Nature for people: health benefits (ART)
Kotera et al., 2022	Nature-based mindfulness	Mental health	Exp	Health	Nature for people: health benefits (SRT; ART)
Mackay and Schmitt, 2019	Psychological (HNC)	PEB	Corr & Exp	Psychology	Nature despite people: landscape management
McMahan and Estes, 2015	Outdoor activities	Mental health	Exp	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT; ART)
Pritchard et al., 2020	Psychological (HNC)	Mental health	Corr	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT; ART)
Spano et al. 2020	Gardening	social domain	Exp	Health	Nature for people; health benefits (therapy)
Vesely et al., 2021	Psychological (HNC)	PE intentions, PEB	Corr	Conservation	Nature despite people: landscape management
Weeland et al., 2019	Mixed contact with nature	cognition	Corr & Exp	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT; ART)
Whitburn et al., 2020	Psychological (HNC)	PEB	Corr	Conservation	Nature despite people: environmental management; People and nature: biophilia
Yao et al., 2021	Mixed contact with nature	Mental and physical health	Exp	Conservation	Nature for people; health benefits (SRT; ART)

Note. HNC: human-nature connectedness; SRT: Stress Recovery Theory; ART: Attention Restoration Theory; PA: place attachment; Corr: correlational studies; Exp: experimental studies. The Attention Restoration Theory (ART) suggests that exposure to nature attracts humans' attention spontaneously and without cognitive cost which allow individuals to develop other costly cognitive abilities (e.g. self-regulation in Weeland et al., 2019) while the Stress Reduction Theory (SRT) suggests that being exposed to nature decreases acute stress and negative thoughts and feeling (Ulrich et al., 1991). Detailed effect size values are provided in Tables A1 and A2 in Online appendix.

outcome" as factors that might explain heterogeneity in effect sizes. We therefore extracted the following factors from the 16 meta-analyses: number of participants, number of studies included, world region where the studies have been conducted (Africa, Asia, Europe, North America, South America and Oceania), age group (children: below 18 years-old, adults: more than 18 years old), type and measure of connection with nature (physical or psychological) and sustainable outcome (e.g. physiological health, self-report well-being; pro-environmental behavior; Tables 1 and 2; Table A1 in Online appendix). We also extracted information about the conservation strategy/framework in which the meta-analysis was done. Meta-analyses that focused on the benefits of nature for humans only were coded as "nature for people" while those which focused on pro-environmental attitudes were coded as "nature despite people." Studies that mentioned the terms biophilia or interdependency were coded as "people and nature" (Tables 1 and 2). We also listed potential limitations and biases (Table 2). Finally, we extracted effect size estimates for each meta-analysis; zero-order Pearson correlations for correlational studies and standardized Means Difference for experimental data that we both transformed into R estimates (Tables A2 and A3 in Online appendix).

3. Results

3.1. Geographic and bibliographic location of studies

Studies were mostly conducted in countries located in North America (42 %), Europe (28 %) and Asia (25 %) while only 3 % were conducted in Oceania and South America, and none in Africa (Fig. 2; Table 2). Additionally, 80 % of the studies were conducted on adults, children were under-represented (Table 2). Most of the meta-analyses (N = 11) were in social science journals (health: 5; psychology: 5; economics: 1) while five were in biological publications (Table 1).

3.2. Categorization of studies

Among the 16 meta-analyses included, half of the papers reported experimental studies while the other half reported correlational studies (Tables 1 and A1 to A3 in Online appendix).

Nine meta-analyses were conducted within the "nature for people" framework in which the utilitarian value of nature for human health is central while five meta-analyses investigated the impact of nature connection on nature conservation within the framework of "nature despite people." Three meta-analyses discussed their results within an evolutionary framework in which the biophilia hypothesis was used to explain the relationships between nature connections, human welfare and nature conservation. The remaining meta-analyses included multiple frameworks ("nature for people" and "people and nature").

3.3. Summary of conclusions

3.3.1. Experimental studies

Meta-analyses of experimental studies showed significant positive effects of physical connection with nature on physical, mental and social health and on socio-cognitive abilities (details and references in Table 1). One meta-analysis showed that physical connection with nature, especially through nature-based mindfulness, improved psychological connection with nature (Barragan-Jason et al., 2021). In turn, psychological connection with nature had a positive impact on pro-environmental behaviors (Mackay and Schmitt, 2019 Fig. 2 and Tables 1, 2, A1 to A3).

The physical connections used in these experiments included natural sounds, outdoor activities, gardening and nature-based mindfulness

Table 2
Description of the limitations and biases identified in the meta-analyses.

Publications	Geographical bias	% of children	k; s	Limitations
Barragan-Jason et al., 2021	North America (43 %), Europe (32 %)	14 %	k = 1019; s = 69,736	Geographical and population biases; no quality control
Bowler et al., 2010	North America (61 %), Europe (23 %)	4 %	k = 45; s = 3674	No confounder adjustment; small sample sizes; geographical and population biases
Buxton et al., 2021	Europe (44 %), Asia (26 %)	Unsp.	k = 116; s = 5369	Small sample sizes; geographical and population biases
Capaldi et al., 2014	North America (71 %)	Unsp.	k = 48; s = 8523	Inclusion of unpublished data; geographical bias
Coventry et al., 2021	Europe (52 %), North America (25 %), Asia (20 %)	0 %	k = 24; s = 4268	Small sample sizes, geographical and population biases
Daryanto and Song, 2021	Unsp.	Unsp.	k = 124; s = 26,273	Unspecified geographical or population information
Djernis et al., 2019	North America (44 %), Asia (32 %), Europe (24 %)	27 %	k = 35; s = 2990	Small sample size; geographical and population biases
Kotera et al., 2022	Asia (84 %)	0 %	k = 59; s = 2062	Small sample size, geographical and population biases
Mackay and Schmitt, 2019	North America (60 %)	18 %	k = 92; s = 4758	Small sample size, no quality control, inclusion of unpublished data, geographical and population biases
McMahan and Estes, 2015	North America (69 %)	Unsp.	k = 51; s = 2356	Small sample size, no quality control, geographical biases
Pritchard et al., 2020	North America (61 %), Europe (26 %)	3 %	k = 50; s = 16,396	No quality control, geographical and population biases
Spano et al. 2020	Asia (57 %), North America (28 %)	0 %	k = 11; s = 825	No quality control, very small sample size, geographical and population biases
Vesely et al., 2021	Unsp.	Unsp.	k = 83; s = 414,282	No quality control, no geographical or population description
Weeland et al., 2019	Europe (60 %), North America (35 %)	100 %	k = 31; s = 110,277	No quality control, geographical and population biases
Whitburn et al., 2020	North America (54 %)	17 %	k = 37; s = 13,237	No quality control, geographical and population biases
Yao et al., 2021	Asia (54 %) and Europe (32 %)	0 %	k = 51; s = 1842	No quality control, geographical and population biases

Note: Unsp.: unspecified. k refers to the total number of effect sizes while s refers to the number of participants included in the meta-analyses.

intervention consisting of being outside while focusing on the present environment. Natural sounds with a higher species richness and with nature-based mindfulness had a higher impact on human health than other treatments (R = 0.29–0.64 and R = 0.19–0.97, respectively; Buxton et al., 2021; Djernis et al., 2019).

Effect size varied widely between experimental studies (Fig. 3). A number of potential explanations are listed in Table 2; they include small sample sizes and absence of controls for quality and for confounding variables as well as a wide variety of well-being measures. Measures of effects on physical health included vitality, stress, cortisol level and pulse rate, while measures of mental health included positive affect, mood, and anxiety. We also observe a lack of experimental studies showing causal relationships between psychological connection with nature and human well-being and no meta-analysis, whether correlational or experimental, investigating links between physical connection with nature and nature conservation.

3.3.2. *Correlational studies*

Meta-analyses of correlational studies supported the relationships revealed in experimental work and, in addition, documented moderate to strong positive associations between human welfare, psychological connections with nature and pro-environmental behaviors (references and details in Table 1). It is questionable to deduce cause and effect from correlational data. However, several authors of correlational studies have used either structural equation models or path analysis to suggest cause-effect relationships, in particular that psychological connection with nature directly affects pro-environmental values, human well-being and health and pro-environmental behaviors. Barragan-Jason et al. (2021) listed these studies, questioned their attributions of cause-effect and called for further experimental studies to confirm causation.

4. Discussion

Our systematic review includes several experimental studies which show that (1) being physically connected with a natural environment is beneficial for human health and improves psychological connection with nature and, (2) being psychologically connected with nature is beneficial for nature conservation. Understanding these relationships and acting on them should assist societies in achieving sustainable outcomes.

However, geographical and age-class analyses reveal an important bias toward adults from the northern regions of the world. In the global North, childhood experiences with the natural world have been shown to predict future sustainable practices (Rosa et al., 2018; Windhorst and Williams, 2015). Determining whether the same relationships hold in the global South is therefore required since countries situated in the South contain hotspots of biodiversity where relevant local values and traditions are particularly important to study. If we are able to understand and predict the impact of global changes on the development of human values, norms, and behaviors, we shall be better able to implement concrete actions to maintain connections with nature throughout life.

Experimental studies have been conducted by researchers from various disciplines with different frameworks, methodologies, statistical analyses and key variables -for example, different types of contact with nature. A scoping review on effects of contacts with nature described different types of such contact, namely indirect (e.g. viewing nature on a video or through a window), incidental (e.g., encountering a tree while going shopping) or intentional (recreational activity such as hiking). Keniger et al. (2013) highlighted the need for conducting experiments to "design landscapes that promote high quality interactions between people and nature in a rapidly urbanizing world." Similarly, in an opinion review, Soga and Gaston (2020) highlighted a lack of studies that include negative interactions with nature, such as being bitten by mosquitoes, along with the more well-studied positive interactions such as recreational activity. Physical connections with nature involving different aspects of the natural environment, such as biodiversity, degree of wildness, and air quality may have diverse effects, mostly positive but some negative. If we are to understand this diversity, future research should include high-quality experimental studies with large

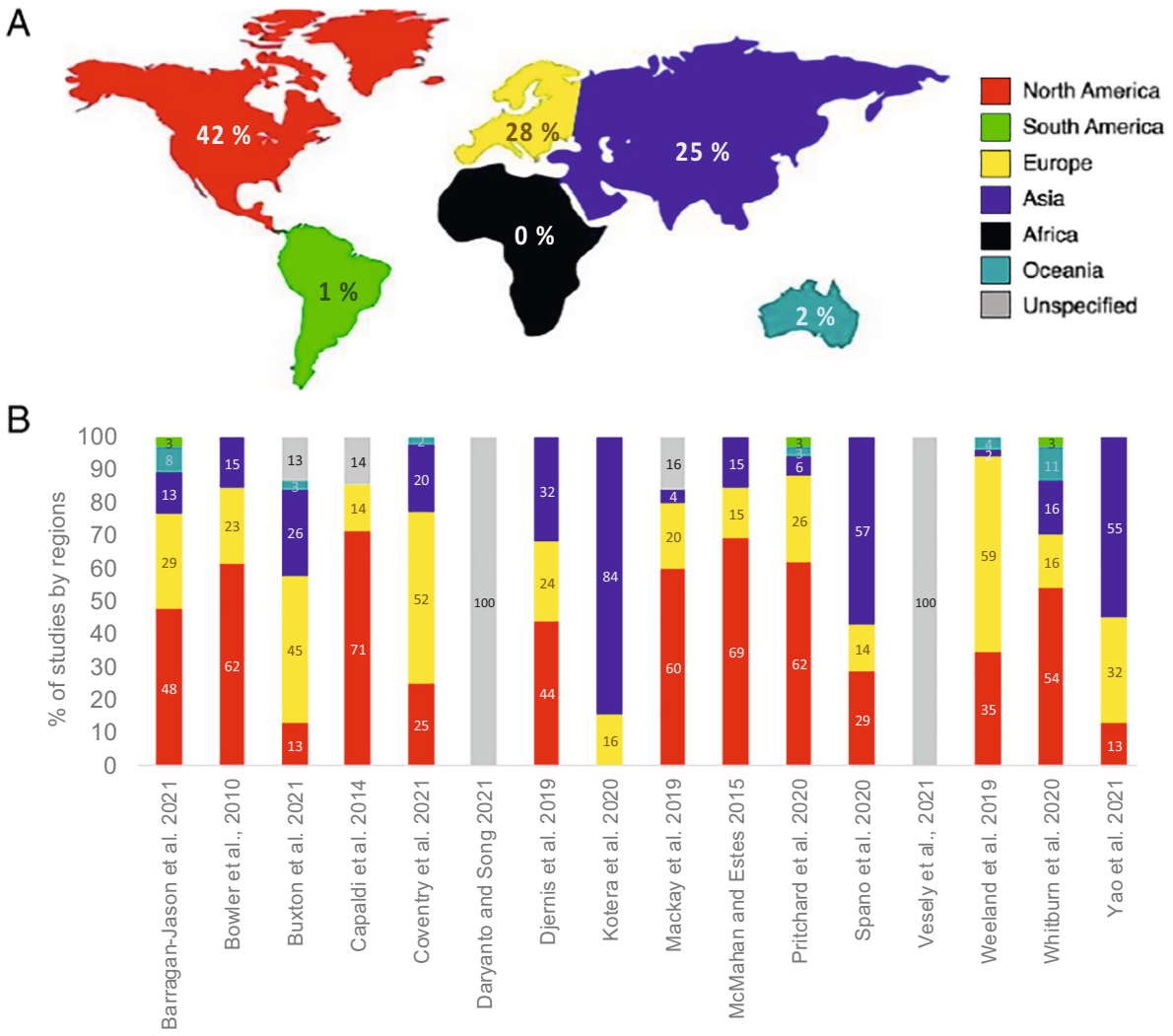

Fig. 2. Geographical description of the studies included in the review. A) Overall percentage of studies by region (North America, Europe, Asia, Oceania, South America, Africa). B) Percentage of studies by world regions for each meta-analysis. Grey color refers to unspecified regions. Most of the studies are strongly biased toward North regions.

sample sizes and sophisticated analyses that would allow distinguishing between the effects of different aspects of the environment.

We note the paucity of experimental studies seeking relationships between connection with nature and nature conservation; Fig. 3 shows only one work in this category, Mackay et al. (2019). This situation may be due to a general anthropocentric bias that has led researchers to concentrate more on human health than on the health of other living beings (Fig. 3). It is unfortunate that the several positive associations between nature connections and Conservation found in correlational studies (Fig. 3) are not yet appropriately supported by experiment, and that robust conclusions about cause and effect cannot yet be drawn. We believe that ecologists and social scientists should collaborate and join forces to fill this gap, a gap that constrains our ability to explore in depth the potential benefits of connecting with nature as a driver of sustainability. The IPBES and the IPCC would likely agree, since both have called for integrating more diverse worldviews into conservation policies, including non-monetary benefits of nature and interdependency between human health and the health of ecosystems (Díaz et al., 2019).

From the present review, two main aspects seem to be particularly beneficial in developing behaviors and values that promote nature conservation/sustainability and improve human health: a high level of biodiversity (acoustic biodiversity in Buxton et al., 2021; landscape wilderness in Djernis et al., 2019) and practicing nature-based mindfulness. These results have substantial implications for devising educational and health policies that are more effective at promoting sustainable development (Huynh et al., 2022; Lumber et al., 2017). As an example, greening urban centers and schoolyards will not only improve urban biodiversity (Filazzola et al., 2019) but will also improve human health, reduce inequality in providing access to nature for all whatever their socio-economic status (Bikomeye et al., 2021; Stevenson et al., 2020; van Dijk-Wesselius et al., 2018) and will improve sustainable values and behaviors (Barragan-Jason et al., 2021). Several initiatives such as the Paris "Oasis" Project in France or the Chicago's Auburn-Gresham in the US have already started in big cities, as well as numerous more local environmental programs (Phenice and Griffore, 2003). Conducting longitudinal studies to evaluate this type of projects as well as developing new efficient long-term research interventions are important considerations for educational and societal policy makers.

5. Conclusions

Reinforcing physical and psychological connection with nature is an important component for achieving conservation goals that can be achieved at moderate cost by greening schoolyards, urban centers, indoor rooms and by promoting nature-based mindfulness in schools and workplaces. Incorporating human behavior and values into conservation

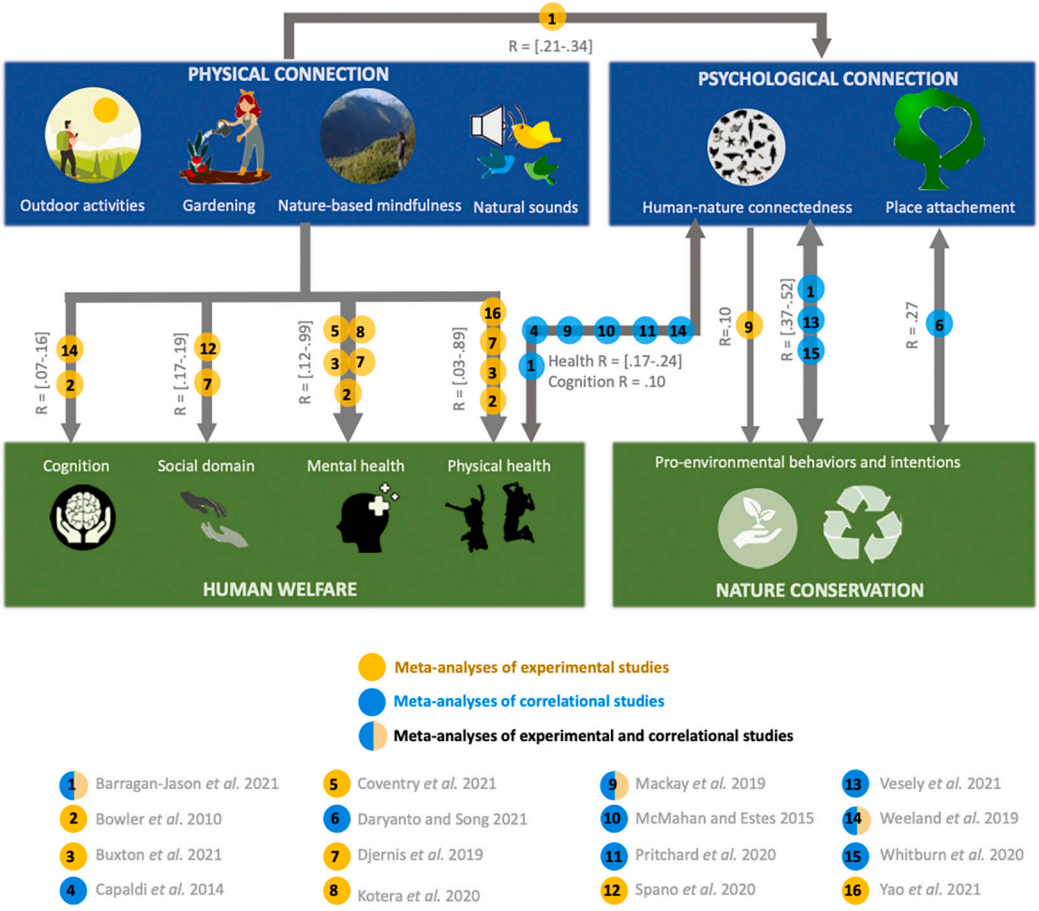

Fig. 3. Results from the systematic review of the 16 meta-analyses. Each round and number represent a published meta-analysis with meta-analyses of experimental studies in yellow and correlational studies in light blue. Connections with nature (physical and psychological) are represented in dark blue while positive outcomes (human welfare and nature conservation) are in green. Single headed arrows refer to causal relations from experimental data while double headed arrows refer to correlations. The thickness of the arrows represents the size of effect. Minimum and maximum averaged effect sizes R reported over the 16 meta-analyses are indicated into brackets when several meta-analyses have been done on the same outcome category. A single R value is provided when only one effect size has been reported (e.g., meta-analysis 6 and 9). All values are reported in Tables A1 to A3.

planning is an underestimated leverage point for achieving sustainability (Hiller and MacMillan, 2021; Travers et al., 2021). We hope that our synthesis will spur increasing valuation of human-nature connections in citizens' daily lives (Nisbet and Zelenski, 2011). To do this should aid in the development of health, educational and conservation policies, and in the forging of desirable and sustainable relationships between humans and other living beings.

CRediT authorship contribution statement

GBJ: Conceptualization, Original and final draft preparation, Methodology; CP: Conceptualization, Supervision, Writing - Reviewing and editing; CM: Conceptualization, Writing - Reviewing and editing; MS: Conceptualization, Writing - Reviewing and editing; ML: Conceptualization, Writing - Reviewing and editing.

Declaration of competing interest

The authors have no competing interests to declare.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2022.109842.

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